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ABSTRACT

Audio-visual media are utilized in this teacher's guide for an interdisciplinary unit in the middle grades. A filmstrip is employed to increase the student's understanding of how pollution problems develop, and some of the steps necessary in working out solutions, as interpretation of historical changes, scientific analysis, and government involvement. The filmstrip is explained in its entirety, illustrating each frame and its accompanying script. Annotated bibliographic notations for teachers are included and divided into three parts: (1) rainfall, hydrologic cycle, and watersheds, (2) fresh water ecology, wetland plants and animals, natural succession in lakes, and marshes, and (3) effects of man-pollution, pesticides, and cultural eutrophication. Resource materials concerning Lake Mendota are also listed. The information is suitable for use in connection with science units on fresh water biology or water pollution and for social studies units related to effects of urbanization or to evaluating the effectiveness of governmental units in handling environmental problems. Filmstrip not included. This work was prepared under an ESEA Title III contract. (BI)

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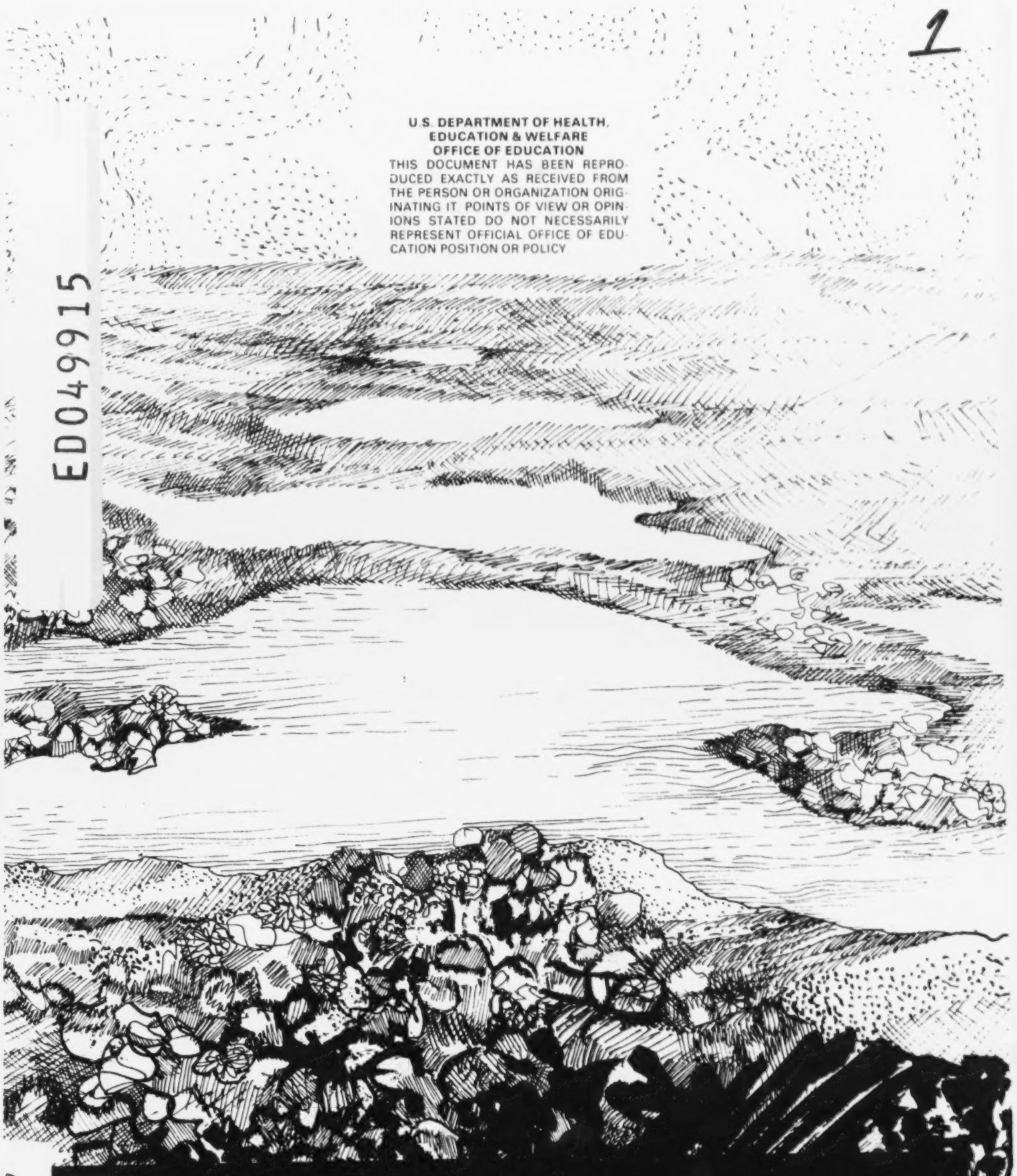

Lake Pollution in the Yahara Watershed

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Instructional Materials About Our Community

a project of...

The Instructional Materials Center
Madison Public Schools
Madison, Wisconsin

"LAKE POLLUTION IN THE YAHARA WATERSHED"

Section I: Teacher Information

A. Objectives and Suggested Use of Materials . . . . . Page 1

B. Vocabulary List. . . . . Page 2

C. Map of Drainage Area of Lake Mendota . . . . . Page 3

D. Chart — Estimated sources of nitrogen and phosphorus. . . . . Page 4

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Section II: Script for filmstrip:

"Lake Pollution in the Yahara Watershed" . . . . . Page 9

The filmstrip and guidebook were produced by the Instructional Materials Center, Madison Public Schools, Administration Building, 545 West Dayton Street, Madison, Wisconsin 53703.

The work presented or reported herein was performed pursuant to a grant from the U.S. Office of Education, Department of Health, Education, and Welfare.

LAKE POLLUTION IN THE YAHARA WATERSHED

OBJECTIVES:

A specific example is used to increase the student's understanding of how pollution problems develop, and some of the steps necessary in working out solutions (such as interpretation of historical changes, scientific analysis, government involvement).

The materials were developed for the middle school interdisciplinary unit on:

"Lake Pollution in the Yahara Watershed"

SUGGESTED USES:

These materials are suitable for use in connection with science units on fresh-water biology or water pollution; and for social studies units related to effects of urbanization or to evaluating the effectiveness of governmental units in handling environmental problems.

VOCABULARY

siltation — filling in by fine particles carried by water.

watershed — the region or area drained by a river or stream.

organic — (organic debris) derived from living things.

algal bloom — sudden development of conspicuous masses of algae.

effluent — something that flows out. The treated liquid waste which comes from a sewage treatment plant is called sewage effluent.

diversion — the act of turning aside from a course. Specifically here, changing the course of sewage effluent to by-pass the lakes.

limnologist — one who makes scientific studies of bodies of fresh water.

eutrophication — the normal process of enrichment and aging undergone by bodies of fresh water.

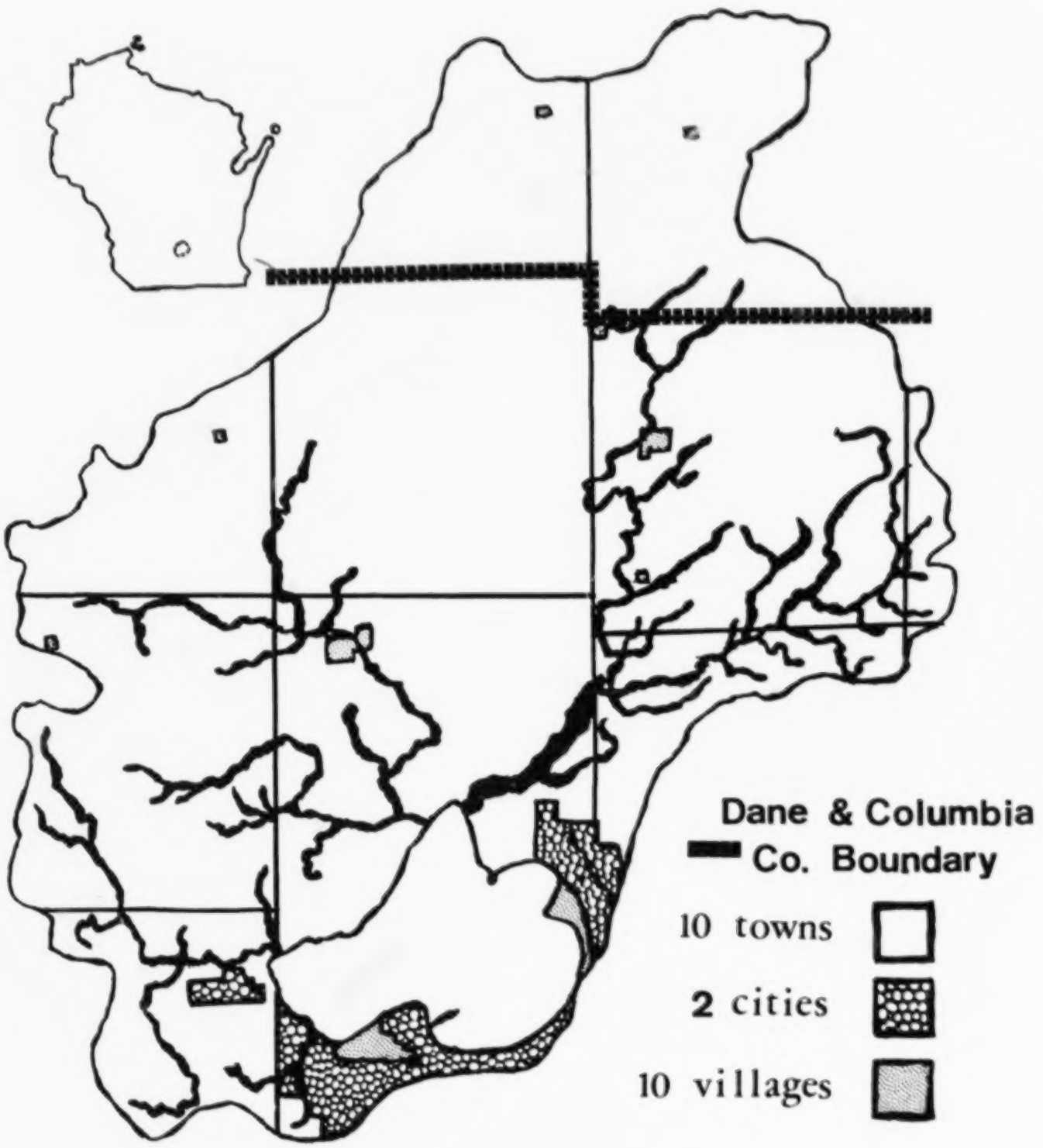
nutrient — a substance which provides nourishment.

Madison has two separate sewer systems:

1. The storm sewer system gathers run-off rain water from the streets and channels it into the lakes. In some areas provision is made for removal of solids through settling, but the water otherwise is untreated. This system is built and maintained by the city.

2. The sanitary sewer system collects household, business, and industrial wastes. These wastes receive primary and secondary treatment at the Nine Springs sewage treatment plant. The plant is operated by the Madison Metropolitan Sewerage District, a separate governmental unit which includes an area larger than the city of Madison.

Drainage Area of Lake Mendota



Estimated sources of nitrogen and phosphorus entering Lake Mendota:

Nutrient Sources	Percent of Total Nutrients Entering Lake Mendota	
	Nitrogen	Phosphorus
Precipitation on lake surface	17	2
Ground Water	45	2
Nitrogen fixation	14	-
Runoff from rural lands (not manured)	1	12
Runoff from manured lands	8	30
Municipal and industrial waste water	8	36
Urban runoff	5	17
Marsh drainage	?	?

LAKE POLLUTION IN THE YAHARA WATERSHED

BIBLIOGRAPHY FOR TEACHERS

General Background on Surface Waters

I. Rainfall. Hydrologic cycle. Watersheds.

* Arnov, Boris Jr. Secrets of Inland Waters. Little, Brown & Co. 1965. Simple explanations of water as a unique substance, hydrologic cycle, formation of lakes, limnology as a science.

* Storer, John H. The Web of Life. Signet. 1953. pp 19-24 "How The Land Gets Its Water" Air currents, rainfall.

II. Fresh Water Ecology. Wetland Plants & Animals. Natural succession in lakes. Marshes.

A. General

* Arnov, Boris Jr. Secrets of Inland Waters. See note above.

* Bates, Marston. The Forest and the Sea. Random House 1960. Chapter 6 "Lakes & Rivers". Contrasts fresh water life with sea life; emphasizes special adaptations for living in rivers, lakes and ponds.

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B. Field Guides:

* Klots, Elsie B. The New Field Book of Freshwater Life. G. P. Putnam's Sons, New York. 1966. Excellent. Includes interesting general information on kinds of fresh water, limiting factors, characteristics of each phylum.

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III. Effects of man.

A. Pollution of surface waters — general.

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B. Pesticides.

* Wis. Department of Natural Resources current releases and pamphlets. Box 450, Madison, Wis. 53701.

* Carson, Rachel. Silent Spring. Fawcett World Library, 1962.

* Rudd, Robert L. Pesticides and the Living Landscape. University of Wisconsin Press, 1964.

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* Hasler, Arthur D. and Ingersoll, Bruce. "Dwindling Lakes". Reprint from Natural History. November 1968. Available from Prof. Hasler, U.W. or on loan from Madison Local Materials Project. Description of the problem and suggestions for coping with it. Dr. Hasler is a world authority in this field.

* Hasler, Arthur D. "Cultural Eutrophication is Reversible". Reprint from Bio Science May, 1969. Available from Prof. Hasler, U.W. or on loan from Madison Local Materials Project. More detailed treatment of the above.

* Restoring the Quality of the Environment. Report of the Environmental Pollution Panel, President's Science Advisory Committee. The White House 1965. Appendix Y9, p 173, "Aquatic Blooms". Complete 18 page summary of the problem and possible remedies. Includes map showing area in U.S. where algae blooms are common in natural lakes.

LAKE MENDOTA

The following materials on Lake Mendota are available on loan from Madison Local Materials Project, 545 West Dayton Street, Madison, Wis. 53703.

I. Background

A. Geology

- Lake Mendota, Origin and History. The Technical Club of Madison 1936. "Geological History of Lake Mendota" by Ernest F. Bean. Fascinating, detailed account by the well known Wisconsin Geologist.

- Sauk Trail Natural History. "Geology and Soils" Simplified account of glacial action in the Middleton-Madison area.

B. Biology

- Lake Mendota, Origin and History. The Technical Club of Madison 1936. "Biology of Lake Mendota" by Edward A. Birge. Brief summary of food production of the lake by the world famous Wisconsin biologist. Interesting foreword by Ernest Bean.

C. History, early uses of the lake. Changes in the watershed.

- Lake Mendota, Origin and History. The Technical Club of Madison. "History of the Lake Mendota Region" by Charles E. Brown. Early settlers, the Indian mound culture. Mr. Brown was the foremost authority on the Indians of this area. "The Dam at the Outlet of Lake Mendota". An account of how the first dam was built with resulting legal problems and a flood.

- Use Of Our Land and Water. Local Materials-ESEA Title III. Filmstrips (or slides) and scripts for classroom use. Includes some history of the use of the lakes, and illustrates changes in the watershed.

II. Today's problems. Cultural eutrophication. Siltation. Pesticides. Suggested solutions.

- Munson, Mrs. Spencer M. Lake Mendota — Problems of Aging. League of Women Voters. Jan. - Feb. 1966. Most complete summary.

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- Recommendations of the Technical Subcommittee to the Lake Mendota Problems Committee for submission to the Dane County Regional Planning Commission. June 27, 1968. Includes watershed map.

* Minutes of the July 18, 1968 meeting of the Technical Subcommittee of the Lake Mendota Problems Committee. Includes reports and recommendations of the Government and Aquatic Plant Control Subcommittees.

* Let's Look at Our Water Resources. A summary of the Madison-Dane County — Water Resource School held in May, 1966. U.W. Extention.

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III. Problems of action: a case history.

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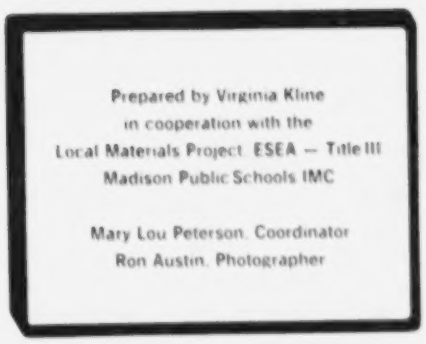
1
Colophon

SPECIAL NOTE:

Please do not judge the quality of the beautiful full-color pictures in the filmstrip by the appearance of the black-and-white photos in this guide! Obviously, there is no comparison between full-color and black and white pictures.

2
Title Frame
LAKE POLLUTION IN THE YAHARA WATERSHED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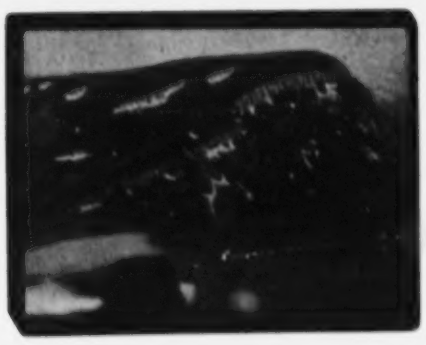
4
There was a time when the Yahara River drained swiftly through a deep valley, carrying water from the surrounding steep hillsides on a long seaward journey. There was no slowing of pace in broad lakes at that time. The river cut through sedimentary rocks to form canyon-like walls similar to these at the Dells today.



5
All this was resculptured by the tremendous slow strength of a glacier. The steep hills were ground down, and the ice wedged its way into the valley, carrying with it tons of rocks and soil. Huge blocks of ice remained in the valley as the glaciers melted back. Torrents of water from the melting glacier carried soil, sand, and rocks into the once deep valley, filling it, and covering the remnant ice blocks.

[Diorama of glacier at Devil's Lake]

6

When the ice at last was gone, the view to the south showed the river flowing through a flattened landscape of gently rolling hills. Extensive flat areas held shallow water. The river was held back in four places by material left by the glacier. Behind each of these glacial dams the water spread out to form a lake. The lakes were deep where the blocks of ice once were buried. The time: 15,000 years ago.

7

All lakes are temporary features of a landscape in geologic time. As soon as a lake is formed the processes of siltation and accumulation of dead plant and animal matter begin working toward its extinction. In the case of the four newly formed lakes the extinction would mean that eventually once again the river would flow on its seaward journey uninterrupted.

8

The natural filling process is extremely slow. The land draining into the four lakes was protected by plants which held the soil. At the time of settlement the soil holding vegetation included large areas of prairie on the rolling hills, cattail marshes and sedge meadows in the wet areas, and a few forests, mostly along the east shores of the lakes.

[A sedge meadow is a wetland dominated by grass-like plants called sedges. Certain kinds of sedges form hummocks, or small mounds. A sedge meadow is wetter than a prairie but not as wet as a cattail marsh. The prairies were maintained by Indian fires which prevented the natural invasion of trees. Since these fires were usually swept by the prevailing southwest winds, the east shores of the lakes were protected from the fires by the lake. Such fire protected areas grew up into forest.]

9
The soils in the watershed were fertile, and the lakes reflected this fertile setting by producing plentiful plants as well as fish and other animals. Indian tribes maintained summer villages on the shores of the lakes to take advantage of the abundant food supply. Plants and animals not harvested accumulated as organic debris on the lake bottoms, part of the long slow process of lake extinction. Occasional algal blooms and excessive plant growth were reported in early records of the lakes.

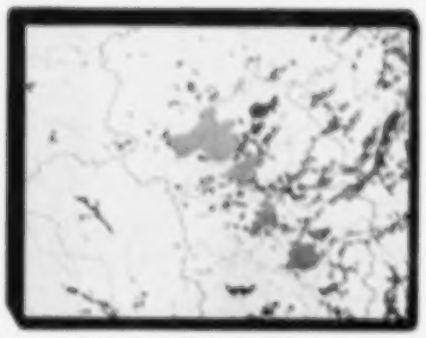
10
So impressive was the beauty of the four lakes that a soldier in a party pursuing Indian leader Black Hawk through the area provided this first written description of the 15,000 year old lakes: "If these lakes were anywhere else except in the country they are, they would be considered among the wonders of the world. But the country they are situated in, is not fit for any civilized nation of people to inhabit. It appears that the Almighty intended it for the children of the forest".

11
But a "civilized" nation of people did come to live in the land of the four lakes, making drastic changes in the watershed — changes which speeded the processes of siltation and organic debris formation.

12
The prairie lands yielded to the plow.

13
Farm animals were introduced.

14
A city of 200,000 plus several small villages developed.



15
Marshes and sedge meadows were drained or filled, some for cropland, some to provide space for the growing city. On this map of Dane County, the light blue areas are wetlands still in existence. The brown areas show the two-thirds of Dane County's wetlands which have been destroyed. Large areas of the city of Madison are built upon former wetland.

16
The material used to fill some of the marshes was the solid waste of the city. Few questioned the wisdom of transforming a marsh into dry land and getting rid of tons of trash in the process.

17
Again few questioned the decision when the blue waters of Lake Monona were chosen to receive another waste product of the city — the treated effluent from the sewage disposal plant.

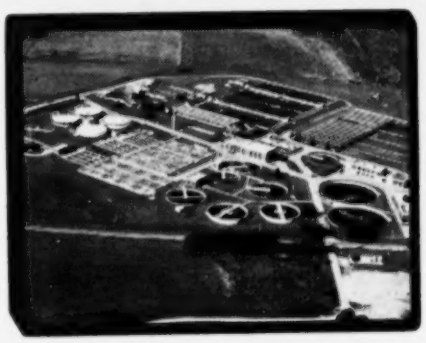
18
The march of concrete, asphalt and shingles invaded more of the watershed. Water which once seeped into the soil and the ground water beneath was intercepted by thousands of roof tops, miles of paved streets and parking lots, and then run into the lakes directly through a storm sewer system.

19
The growing population and increased leisure time put increased demands on the lakes for recreational purposes — boating, swimming, fishing, and just pleasure driving along the lakeshore.

Man's changes in the watershed and his increased demand for beautiful recreational lakes were on a collision course.

20
The first sign of the collision was seen in Lake Monona where foul smelling algal growth developed which was attributed to the city's sewage effluent. In 1938 the effluent was diverted downstream from Lake Monona.

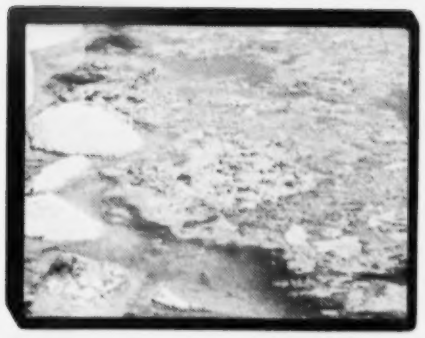
21
Improvement of Lake Monona following diversion was striking. However Lakes Waubesa and Kegonsa, downstream from Lake Monona, then began to show the harmful effects of the effluent.



22
By the late 1950's all sewage effluent from Madison was diverted from all of the lakes. This is the Madison Metropolitan Sewerage District Treatment Plant which handles Madison area sewage today.

[The Madison Metropolitan Sewerage District is a special governmental unit set up to handle sewage treatment for an area larger than the city of Madison. The treatment plant is called the Nine Springs plant, and is located south of Madison. It is named after a nearby stream thought to be fed by nine springs in the area.]

23
The effluent from the plant, after chlorination, is channeled into Badfish Creek and joins the Yahara River below the four lakes. Madison thus "solved" its effluent problem by sending it farther downstream.



24

The respite was only temporary. By 1965 the Madison papers were describing Mendota as a stinking mess, a dying lake. The time: less than 150 years since the first settlers arrived. In response to public concern, the Mayor of Madison appointed a Lake Mendota Problems Committee.

[Otto Festge was then mayor.]

25

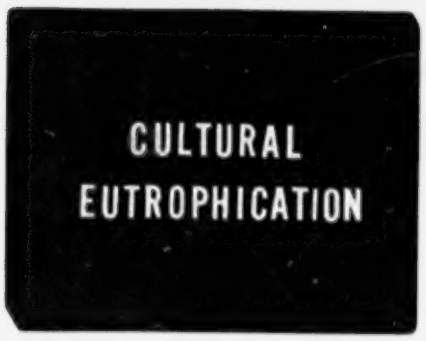
Chairman of the Technical Subcommittee of the Lake Mendota Problems Committee is Dr. Arthur Hasler of the University of Wisconsin, a world renowned limnologist. His committee includes experts from the University, the Wis. Department of Natural Resources, and the city.

[Limnology — the scientific study of fresh waters.]

26

Lake Mendota had long been one of the most studied lakes in the world due in part to the work of Edward Birge, a University of Wisconsin scientist who pioneered in the study of fresh water lakes.

[Picture courtesy of State Historical Society of Wisconsin.]



27

The Technical Subcommittee examined all available data on Lake Mendota, consulted studies made on other lakes, and reported on their findings. Their diagnosis: The natural aging process, called eutrophication, through which a lake is very gradually filled in, is being greatly accelerated by the changed land use in the watershed. This speeding up aging is referred to as cultural eutrophication.

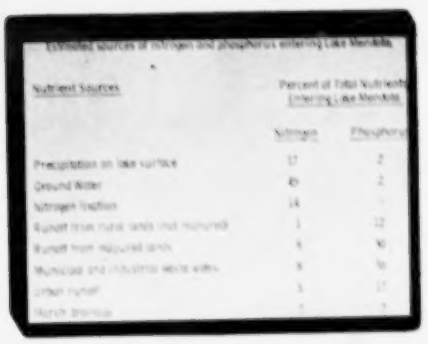
28

Siltation and accumulation of organic material, the two processes through which lakes age, have both been increased by the watershed changes. Siltation has increased because man lays the earth bare with plow and bulldozer. Marshes which once provided settling basins for silt have been drained and filled so that more silt now goes directly into the lake.

[Siltation at mouth of Pheasant Branch Creek]

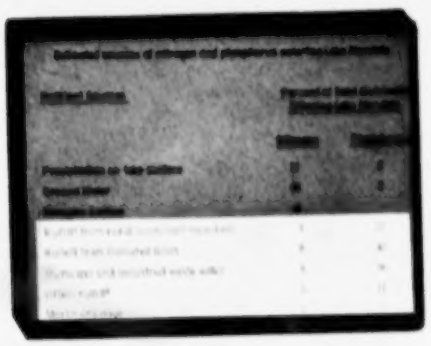
29
Increased growth of plants in the lake is due to increased amounts of plant nutrients being washed in. The lake is overfertilized and the water plants respond just as a lawn or garden does when fertilized. Luxuriant bottom rooted plants such as water milfoil, shown here, interfere with boating and swimming.

30
Excessive algal growth forms a green scum and creates an odor nuisance as it decays. The decaying process uses up dissolved oxygen in the water. Lowered oxygen levels in the water seriously affect fish and other aquatic animal life.



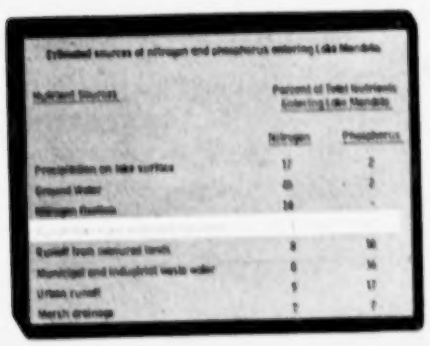
Nutrient Sources	Percent of Total Nutrients Entering Lake Mendota	
	Nitrogen	Phosphorus
Precipitation on lake surface	17	2
Ground Water	45	2
Nitrogen fixation	14	-
Runoff from rural lands (not manured)	1	12
Runoff from manured lands	5	10
Municipal and industrial waste water	5	10
Urban runoff	1	17
Marsh drainage	1	7

31
Two vital nutrients for plants are phosphorus and nitrogen. This chart shows the sources of these two nutrients in Lake Mendota and the estimated per cent that comes from each source. Since the plants need both in order to grow, control of all the sources for either nitrogen or phosphorus would limit plant growth in the lake.



32
The main sources of phosphorus appear to be more readily controllable by man (why?). This is the reason the main thrust of the effort to improve the lake has been directed toward reduction of the amount of phosphorus entering the lake.

(Note that urban and rural run-off, the cause of the siltation problem, are major sources of phosphorus as well.)



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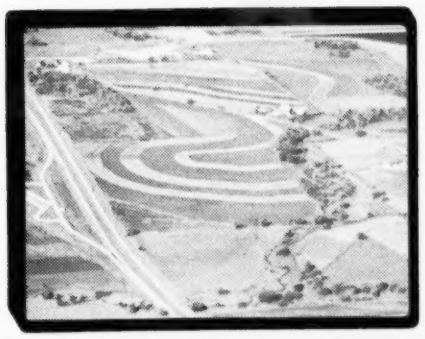
Municipal and industrial waste water	5	10
Urban runoff	1	17
Marsh drainage	1	7

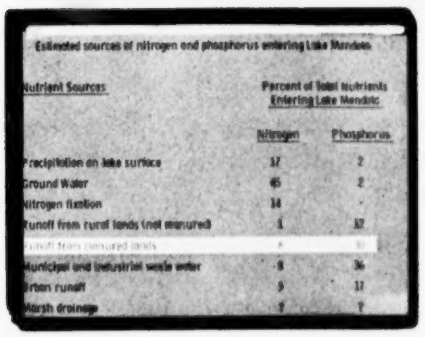
33
Run-off from rural lands (not manured) accounts for an estimated 12 per cent of the phosphorus entering the lake.



34
Control depends on good agricultural soil conservation practices including contour strip cropping . . .

35
. . . and fencing of stream sides and woodlots to keep cattle out. These practices are generally followed in the watershed . . .

36
. . . but this picture of streamside land with exposed soil due to overgrazing was taken along a small stream which flows into Lake Mendota.



Estimated sources of nitrogen and phosphorus entering Lake Mendota

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Precipitation on lake surface	17	2
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Nitrogen fixation	14	-
Runoff from rural lands (not manured)	1	17
Runoff from manured lands	4	30
Municipal and industrial waste water	8	36
Urban runoff	9	11
Marsh drainage	2	2

37
Run-off from manured lands accounts for an estimated 30 per cent of the phosphorus entering the lake.

38
It is standard procedure for farmers to spread manure on their fields. This not only disposes of the manure but, during most of the year, returns the nutrients in the manure to the soil to fertilize the farm crops.

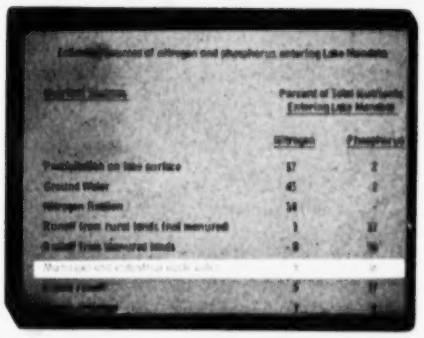
[Manure has been spread on the right half of this field.]

39

In winter however, the soil is frozen when the manure is spread. Spring rains carry the nutrients off the frozen soil and into the streams that flow into the lake. There the nutrients fertilize not farm crops but water plants. Control involves such methods as building tanks to hold the manure until the ground thaws, at which time it can be pumped out onto the land. This is a costly procedure. Who should pay for it?

40

The manure problem is aggravated in feed lots because of the high concentration of cattle. Control of feed lot concentration or perhaps treatment of feed lot wastes may be necessary.

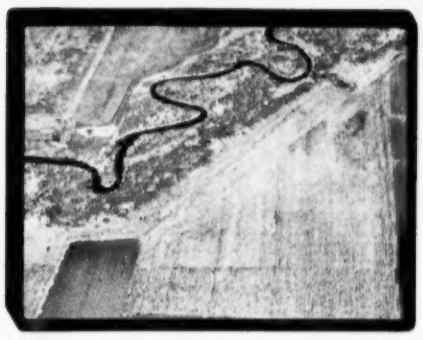


41

Municipal and industrial waste water accounts for an estimated 36 per cent of the phosphorus entering the lake.

42

The villages of Windsor, Waunakee and DeForest are upstream from Lake Mendota. (The light blue area is the Yahara watershed in Dane County.)

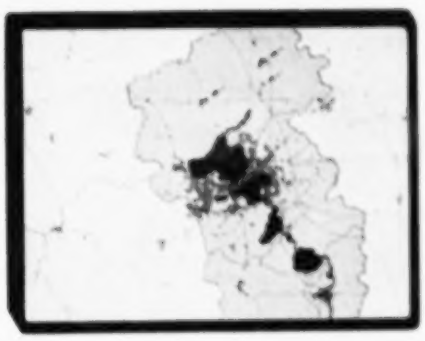


43

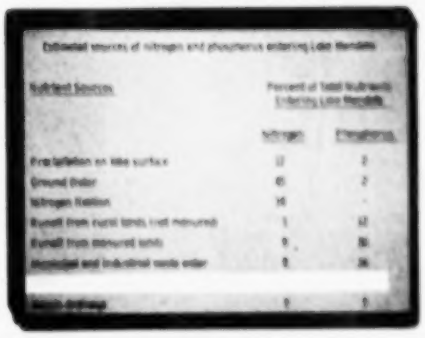
Treated sewage effluent from these communities is run into Six Mile Creek and the Yahara River, the most convenient receptors. Water from these streams flows into Lake Mendota. The effluent, although sanitary, contains considerable phosphorus as well as other plant growth substances. Note that these villages are disposing of their effluent in a manner similar to that used by the City of Madison.

[Six Mile Creek]

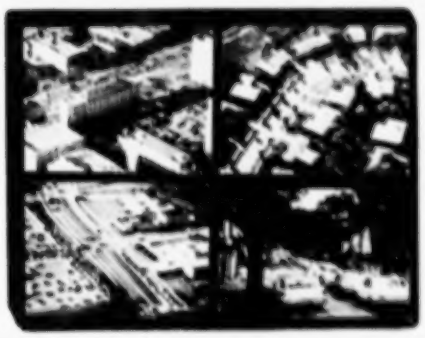
44
In 1965 the Wisconsin Legislature passed a law which requires the communities upstream from Lake Mendota to stop putting nutrient-laden effluent into the streams by 1970. Norman Anderson, Assemblyman from Madison's east side, was instrumental in securing passage of the law.



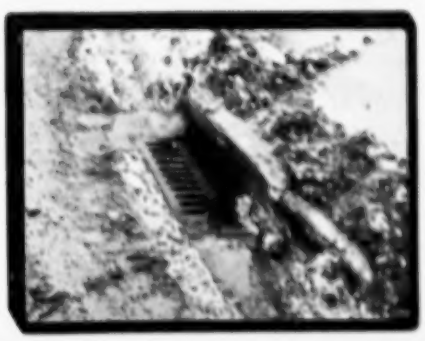
45
To comply with the law, the villages involved are planning to connect their sewage systems to the Madison Metropolitan Sewerage District, thus by-passing the lakes. Notice how far to the south the effluent will have to be piped in order to by-pass the lakes. Progress has been slow partly due to financing problems. Meeting the 1970 deadline will be difficult. When the diversion is completed, it is possible that Lake Mendota will show the striking improvement shown by Lake Monona after diversion of Madison's effluent. Diversion, however, is not an ideal long term solution since it only passes the problem on downstream.



46
Urban run-off accounts for an estimated 17 per cent of the phosphorus.



47
Roof tops, sidewalks, streets, and parking lots keep water from soaking into the ground where it could be naturally filtered by the action of roots and soil organisms. Instead the water is channeled into storm sewers which empty directly into the lakes.



48
The water carries with it waste from automobiles, litter, soot, chemicals used in de-icing streets, — all the varied souvenirs of city activity.

49

Citizens of Madison should be made aware that any material they allow to get into storm sewers is a potential hazard to the lakes. For example, leaves burned in the gutter leave ashes containing plant nutrients which will be carried into the storm sewer by the next rain. Enforcement of Madison's leaf burning ordinance would prevent this.

50

Fertilizers applied to suburban lawns too liberally or in a way that allows run-off into the street will end up fertilizing the lake plants. A study has been started to obtain data on the lawn fertilizer factor. Compounds which act as fertilizers should never be used for de-icing sidewalks.

51

One former source of phosphorus has been eliminated. Car washes in Madison use large quantities of detergent. Detergents are compounds high in phosphorus. Waste water from car washes formerly drained into storm sewers, but through efforts of the Madison Health Department all car washes in the city now are connected to the sanitary sewer. Car owners who wash their own cars at home should not allow detergent to enter storm sewers.

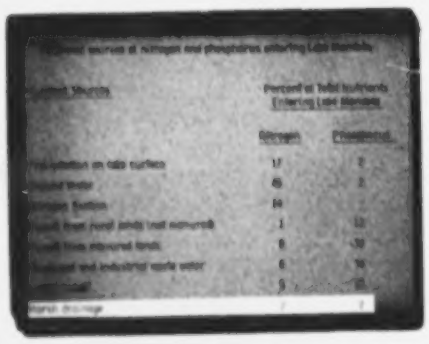
52

A major run-off problem is the unprotected soil resulting from grading and excavation in urban areas. There is at present no requirement by any of the government units in the watershed that exposed soil be protected by mulch, plastic or other material.

53

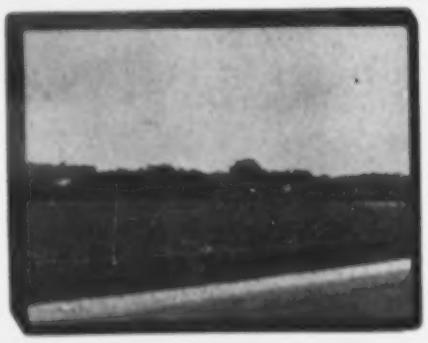
The City Engineering Division has created some greenways and settling basins which help to prevent the soil from traveling all the way to the lake. Here you can see the Schenk Park greenway with settling basin in the background. When the storm water is allowed to run into a wide area such as this, its velocity is reduced, which causes it to drop its load of solid particles. Such settling basins may require periodic removal of accumulated silt.

54
This greenway is on the far west side of the city. The strip of concrete in the bottom, called a cunette, helps prevent formation of a gully in the channel.



55
The amount of phosphorus and other nutrients which has been released by draining marshes into the lakes is not known. Many scientists, however, feel that this is a significant factor contributing to the present condition of the lakes.

56
In addition, marshes are settling basins for silt-laden run-off water and provide wildlife habitat.



57
Yet in spite of the knowledge of the value of wetlands, the draining continues. Here a wetland area close to Lake Mendota has been drained to allow a blue grass park lawn — that standard symbol of suburbia — to be planted.

58
Note the muddy water in the drainage ditch which flows into the lake.

59
An (as yet) undrained area across the road has rich variety of plant life, animal habitat, natural beauty, and freedom from maintenance. Education can perhaps develop wider appreciation of such areas.

60
The Wisconsin Department of Natural Resources and the City of Madison have purchased large areas of the Cherokee Marsh along the Yahara River north of Lake Mendota. These areas will thus be protected. Purchase of a wetland for conservation purposes by a city is unusual. An outdoor education program has been started in the city owned area for Madison students.

61
Unfortunately, in spite of a long dispute, the city was not successful in preserving another part of the marsh. Here an area was developed for housing, and an artificial lake was dredged. The extent of the damage to Lake Mendota as a result of this activity can only be estimated.

[For further information see "Cherokee Marsh: Win-Draw-Compromise?" by Ruth Bauman, University of Wisconsin Extension.]

62
Use of pesticides in the watershed poses a special problem. When elms in the urban area were attacked by Dutch elm disease as shown here, Madison and other lakeshore communities sprayed DDT, a persistent insecticide, in attempts to control the disease.

63
DDT entered the lake via storm sewers and was found greatly concentrated in the bodies of fish. Increasing scientific evidence of the damaging effects of DDT and related chemicals on living things including man has resulted in demand for stricter controls. Use of DDT is now prohibited by Wisconsin law, but DDT is so long lasting that it will persist in the environment for years. Ideally any pesticide used in the watershed should be specific for the target pest, degrade quickly, and be applied with restraint.

64

The discussion thus far has been related to preventative methods in the watershed. In the lake itself plant harvesting can decrease the nuisance to swimming and boating. Since the plants contain nutrients the harvest helps to remove some nutrients from the lake. Use of herbicides to kill lake plants on the other hand kills the plants but allows them to decay so that the nutrients are available for further plant growth.

65

Summer and ice fishermen, boaters, swimmers, and lakeshore spectators could do much to prevent debris accumulation in the lake and on the shore. A vigorous and continuing shoreline clean-up program could remove rotting fish and plants as well as litter.

66

In talking about the problems of the lakes, it's always easier to discuss what should be done than who should do it. Consider the many governmental units represented in the Mendota watershed. Who should be responsible for planning, enforcing, and financing the remedial measures? The City of Madison? Dane County? A new unit of government such as a watershed district?

67

How much is it worth to have beautiful recreational lakes in an urban setting . . .

68

. . . instead of this . . .

69
. . . or this?

70
For 15,000 years the lakes supported a rich and varied plant and animal population.

71
Must 150 years of a growing human population destroy the natural balances that maintained such a quality environment?

72
The End.